

Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

a SD388
A145
cop. 2

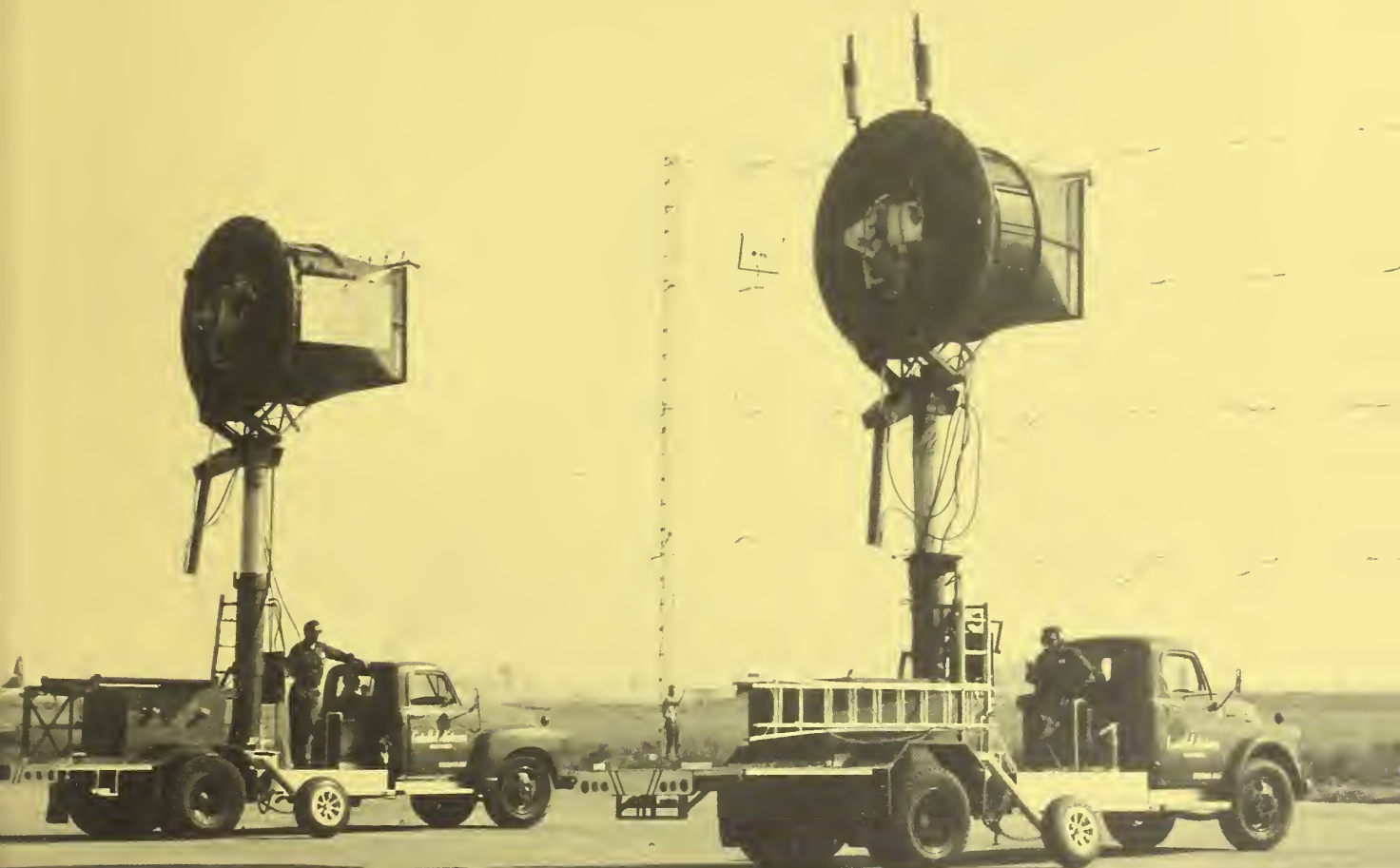
TECHNICAL EQUIPMENT REPORT NO. AC 5100-8

August 1962

EVALUATION OF CONTROLLED AIRSTREAM BLOWERS

By

ARCADIA EQUIPMENT DEVELOPMENT CENTER
ARCADIA, CALIFORNIA



ADMINISTRATIVELY CONFIDENTIAL. For official use of U. S. Government and cooperating personnel only, reference USDA Security Regulation, section 3b-1, and USDA Administrative Regulations 3 AR 47 and 3 AR 405.



U.S. DEPARTMENT OF AGRICULTURE / FOREST SERVICE / WASHINGTON, D.C.

SUMMARY

On October 19 and 20, 1960, the Arcadia Equipment Development Center and the Pacific Southwest Forest and Range Experiment Station jointly conducted tests to evaluate the flow characteristics of Controlled Airstreams blowers. The main tests were conducted at Chino Air Attack Base, Chino, California. The final water dispersion tests with the small blowers were completed at the Arcadia Work Center on November 1, 1960.

Two 72-inch and four 18-inch blowers were submitted for test. All had nozzles and straightening vanes for directional control. The large units were truck-mounted--the smaller ones were hand-carried.

Air flow velocities and patterns were measured on a grid target. The effect of the airstreams on smoke columns was studied. Water and a bentonite fire retardant were dispersed.

Directional control was good. No recirculation or clamshell pattern was established. Large quantities of water and bentonite were evenly applied.

In calm air the large blowers could effectively handle large air masses but could not noticeably influence ambient winds approaching 10 mph.

The small blowers were unable to alter the general smoke column in calm air but did fan the flame to a high intensity. They could prove useful in backfiring and slash-burning activities.

TECHNICAL EQUIPMENT REPORT NO. AC 5100-8

August 1962

EVALUATION OF
CONTROLLED AIRSTREAM BLOWERS

By
Arcadia Equipment Development Center
Arcadia, California

Charles W. Howard Supervising Engineer
Frank M. Winer Test Engineer

Forest Service - U.S. Department of Agriculture

TABLE OF CONTENTS

SUMMARY	i
INTRODUCTION	1
EQUIPMENT	2
INSTRUMENTATION	5
AIRSTREAM MEASUREMENTS	6
Test Site Plan	6
Procedure	7
Results.	7
SMOKE TESTS	11
Near Zero Ambient Winds	11
Turbulence Check	11
Clamshell Check	13
Cross Winds with Large Blowers	14
Head Winds with Large Blowers	15
Small Blowers	17
WATER DISPERSION	18
Large Blowers	18
Small Blowers.	19
BENTONITE DISPERSION	20
COMMENTS	21
CONCLUSIONS	25
APPENDIX I	26
APPENDIX II	27

INTRODUCTION

For many years blowers have been advocated as a tool to aid in the control of wildland fires. It has been suggested that countering the ambient wind would reduce fire spread and that a controlled wind would help in backfiring. On a limited scale this concept was explored prior to these tests.

In 1938, a high-capacity, tractor-mounted centrifugal blower was tested at Cuyama, California. A similar test was made again in 1955 with a larger truck-mounted, axial-flow blower. * Both failed because of lack of control, excessive turbulence and because the discharged airstream tended to circle the machine and re-enter the blower, carrying fire with it. Fire could engulf the blower and endanger operating personnel. This circling characteristic is often called "clamshell" effect. Due to the clamshell effect and the other limited advantages obtained, the use of blowers on fires was not recommended.

Later Controlled Airstreams, Incorporated, became interested in the application of airstreams on fires. After studying the problem and reviewing results of earlier tests, they concluded that past failures were caused by faulty equipment and technique.

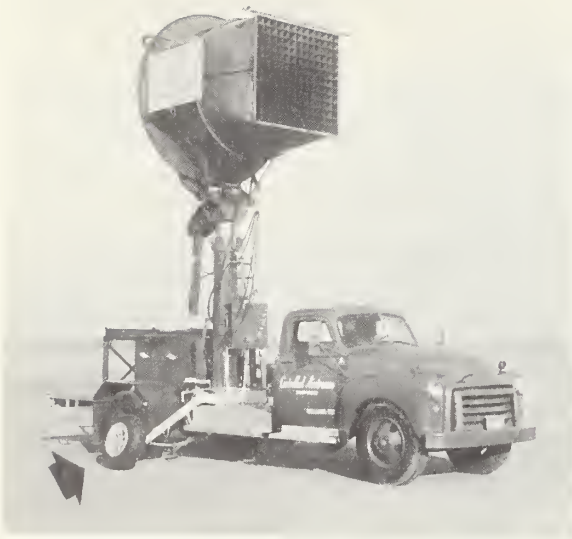
With this background, the company designed two sizes of axial-flow blowers, a larger unit with 72-inch blades and a smaller size with 18-inch blades. All had nozzles and straightening vanes for directional control. The large units were for truck mounting; the small sizes, for hand carrying.

The first large wind machine was demonstrated at Arcadia in July 1960. It appeared to be a well-built finished product, evidently the result of much thought and development. In the brief demonstration, airstream directional control was good.

In October 1960, this Center and the Pacific Southwest Forest and Range Experiment Station jointly conducted a series of tests at the Chino Air Attack Base in Chino, California. The tests encompassed the large and small blowers but were limited to determining volume and control of the airstream and its ability to carry and disperse water or fire chemicals. Particular attention was placed on eddy currents, clamshell effect, and the stability of the airstream in ambient winds.

*Firestop Progress Report No. 8, "A Wind Machine and Fire Control", June 1, 1955.

EQUIPMENT



■ SQUARE NOZZLE with blower in lowered position. Note outrigger wheels to prevent tipping.

■ ROUND NOZZLE with blower in raised position. A spare square nozzle was carried on rear.



■ Ready for highway travel.

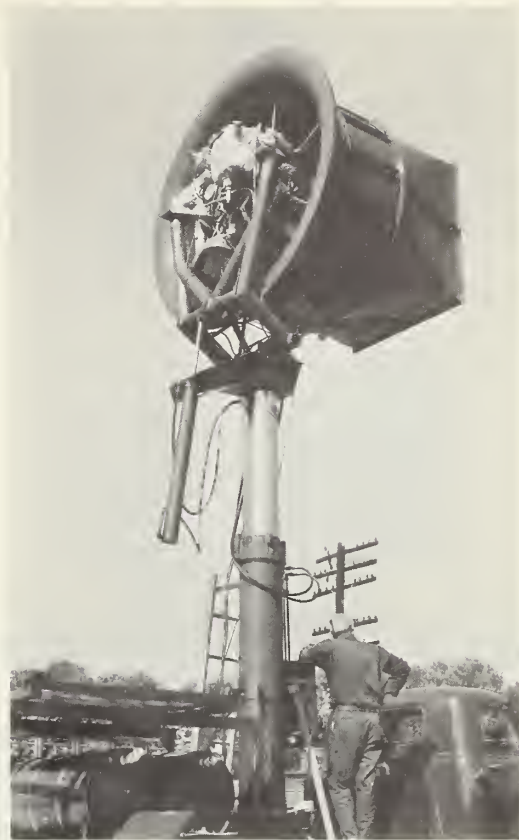
- Inlet side of blower.
Note tilting cylinder
and hinge assembly.

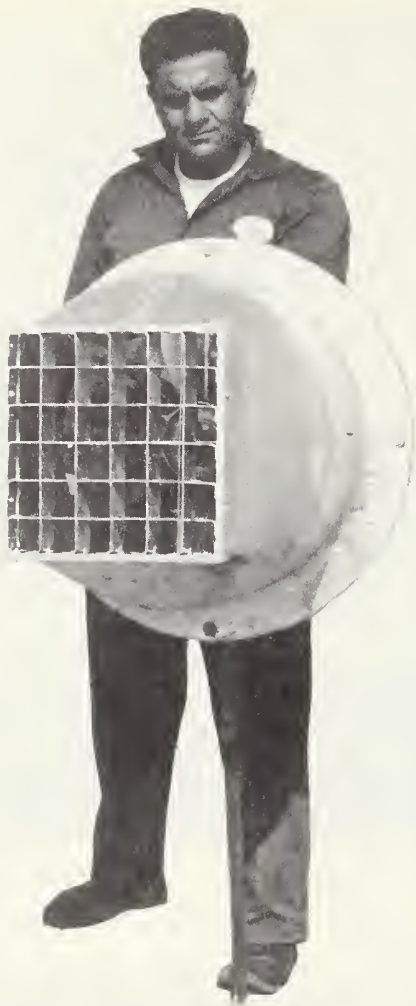
THE LARGE BLOWER

The axial flow blower was powered by a 250 horsepower aircraft engine. Air entered through a curved inlet section and was forced through the outlet section or nozzle by a 72-inch propeller. Two sets of straightening vanes were used to eliminate swirl and insure directional control.

A large hydraulic cylinder provided adjustment of the blower unit to a maximum of 20 feet and permitted hand rotation of the blower for horizontally aiming the airstream in any direction. A small hydraulic cylinder raised the blower from its travel position and tipped it to control vertical aim. Power for both cylinders was supplied by a hydraulic pump on the truck engine.

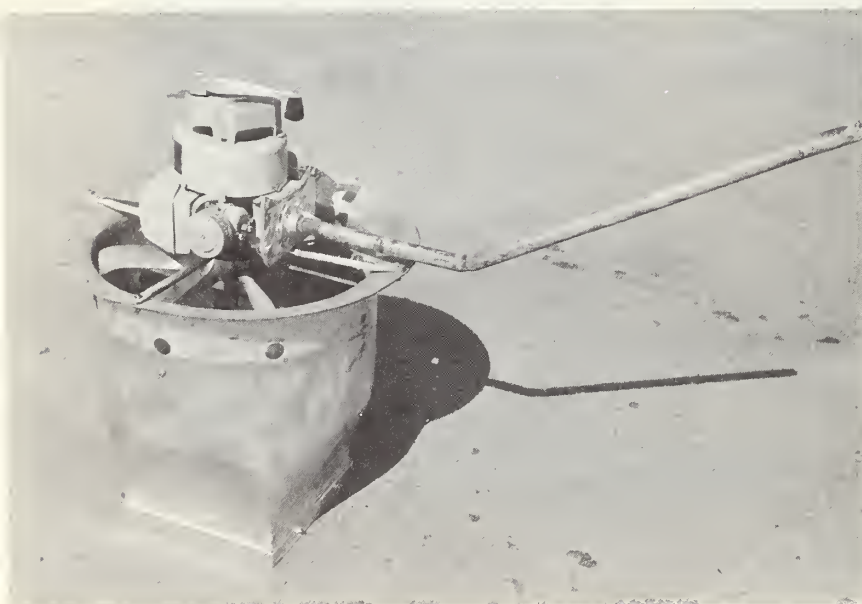
- Blower control panel





THE SMALL BLOWER

The 18-inch blowers had outer shells of fiberglass material with the inlet, outlet and center sections constructed of one piece. The 7-blade, 18-inch diameter fan blade was driven by a Clinton 2.5 horsepower engine. A manually wound spring type of self-starter was included. The units tested at Chino were supported by a stand made from a single length of pipe. The operator balanced the unit at chest height without having to support the weight of the blower. In later tests conducted at Arcadia, a four-legged pipe stand was provided which enabled the machine to stand alone. A complete unit weighed approximately 45 pounds.

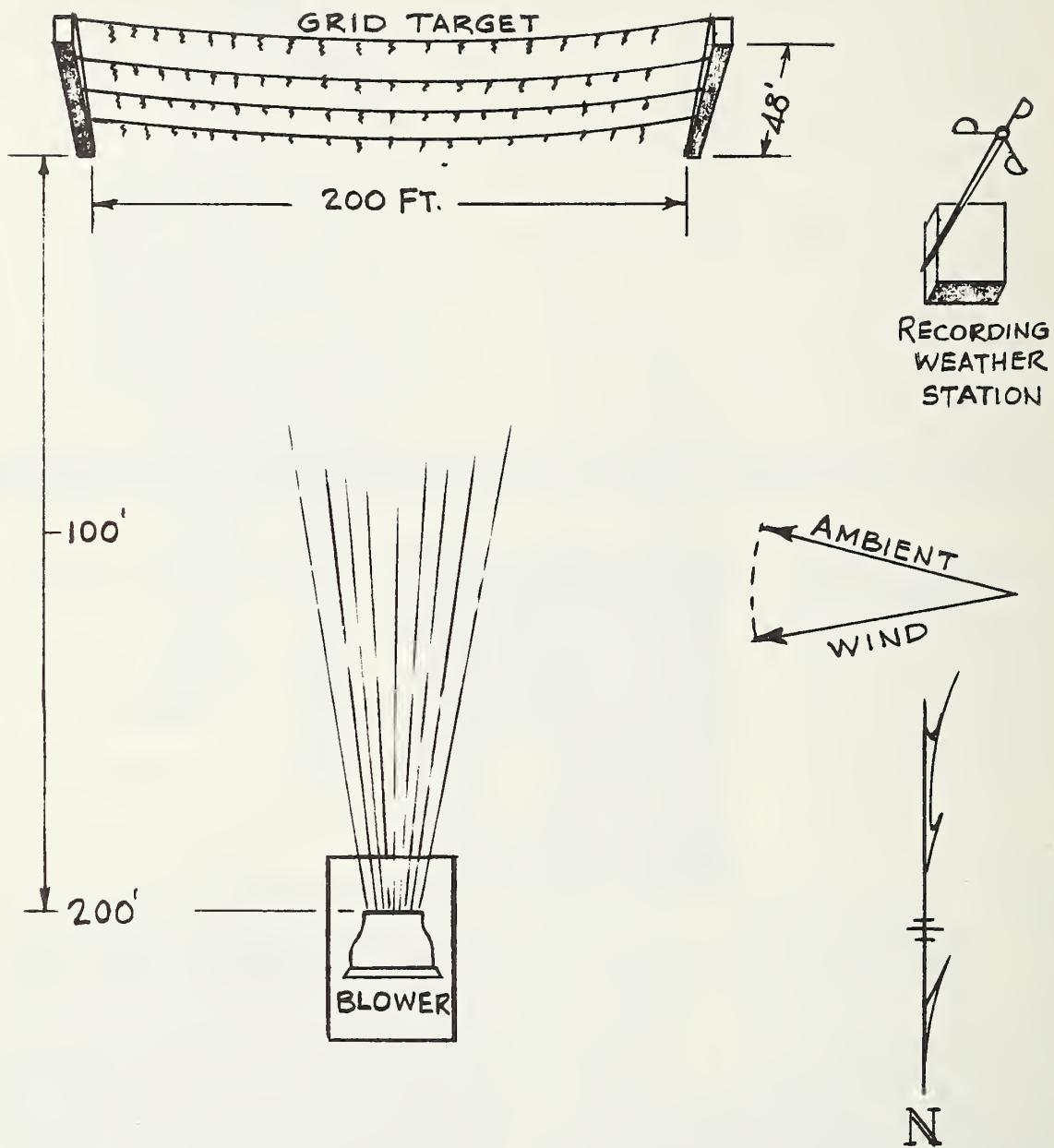




INSTRUMENTATION

A wind grid was erected, 48 feet high by 200 feet long. A portable weather station was set up to record ambient weather conditions and wind velocities on the grid.





TEST SITE PLAN

AIRSTREAM MEASUREMENTS



PROCEDURE

Velocity of wind on target was measured by an anemometer in a rolling carriage 46 feet above the ground. Horizontal measurements were made at 20-foot intervals across the grid. To obtain velocities at various elevations the blower was tipped to produce a 20-foot change in projection at the grid. A large protractor and pendulum on the side of the blower provided a basis for vertical adjustment. Streamers at 10-foot intervals gave a visual indication of air movements.

RESULTS

The airstream isograms show the wind velocities at the grid as viewed from the blower. Instrumentation did not permit taking instantaneous air speeds over the grid target. Instead, a single anemometer had to be moved from point to point to measure velocities; this consumed from 30 to 60 minutes for each test. During this time, ambient winds changed in both direction and velocity. In the isograms shown, the wind direction was changeable from west to northwest and varied from zero to 3 mph. The indicated velocities through the grid have been corrected for the influence of these ambient winds, but no attempt was made to adjust for direction. The distortion to the left in each case was the result of these winds.

The round nozzle at 100 feet produced a good pattern about 60 feet in diameter with velocities up to 20 mph at the center. At 200 feet the pattern had spread off the grid and was quite uneven with a maximum velocity of 8 mph. The areas between the zero lines represent negative velocities or air movement toward the blower.

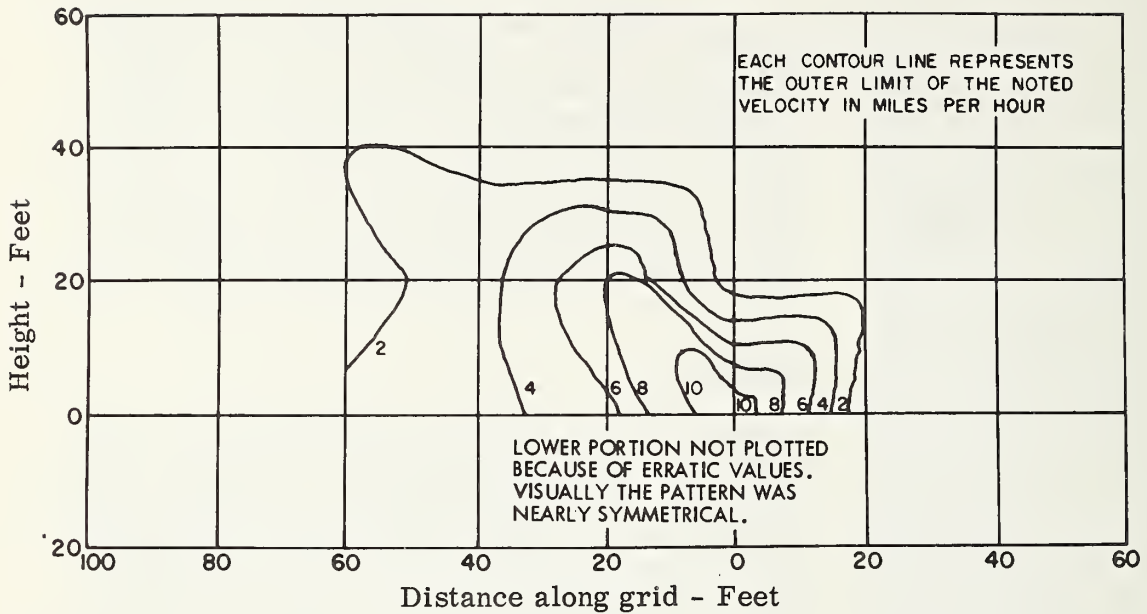
The square nozzle at 100 feet formed a compact pattern concentrated in a 60-foot diameter. The peak velocity was about 10 mph. At 200 feet the pattern increased only slightly in size and still had the same maximum velocity.

Comparatively, the round nozzle put out a tight pattern which spread out of control at 200 feet; whereas the square nozzle created as tight a pattern with less velocity at 100 feet but maintained its form and speed fairly well past 200 feet.

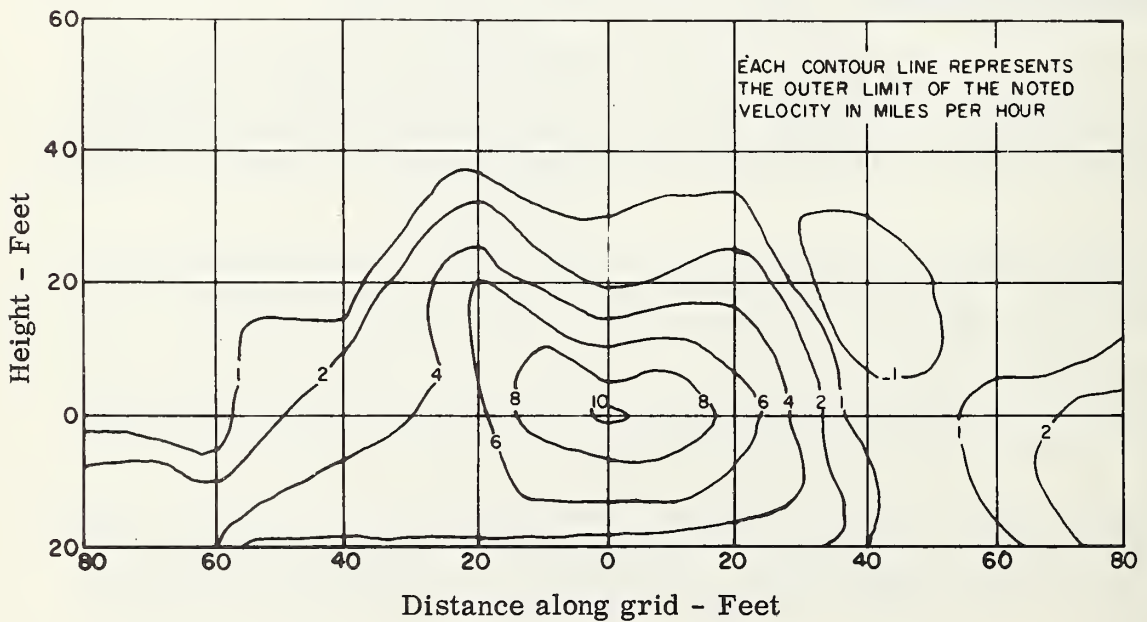
The patterns shown are representative of average conditions. Under zero ambient wind conditions, control was appreciably better as was indicated visually by the streamers on the grid target. The square nozzle showed extremely sharp boundary conditions with little edge turbulence and no flags flying in a reverse direction.

AIR VELOCITIES WITH SQUARE NOZZLE CORRECTED FOR AMBIENT WIND VELOCITY

AT 100 Feet

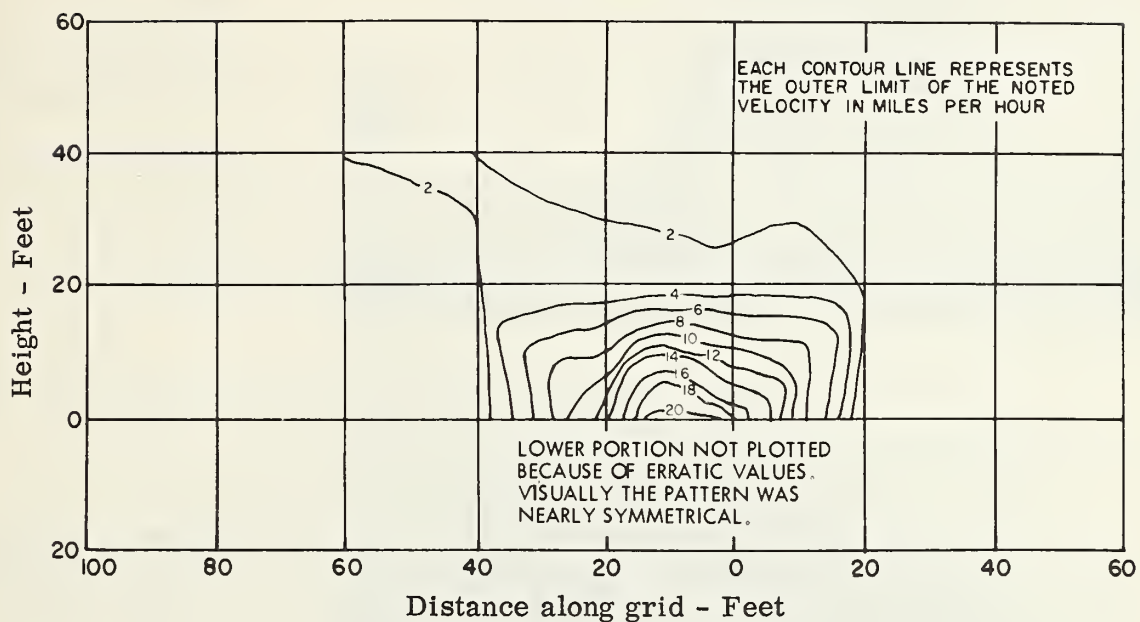


AT 200 FEET

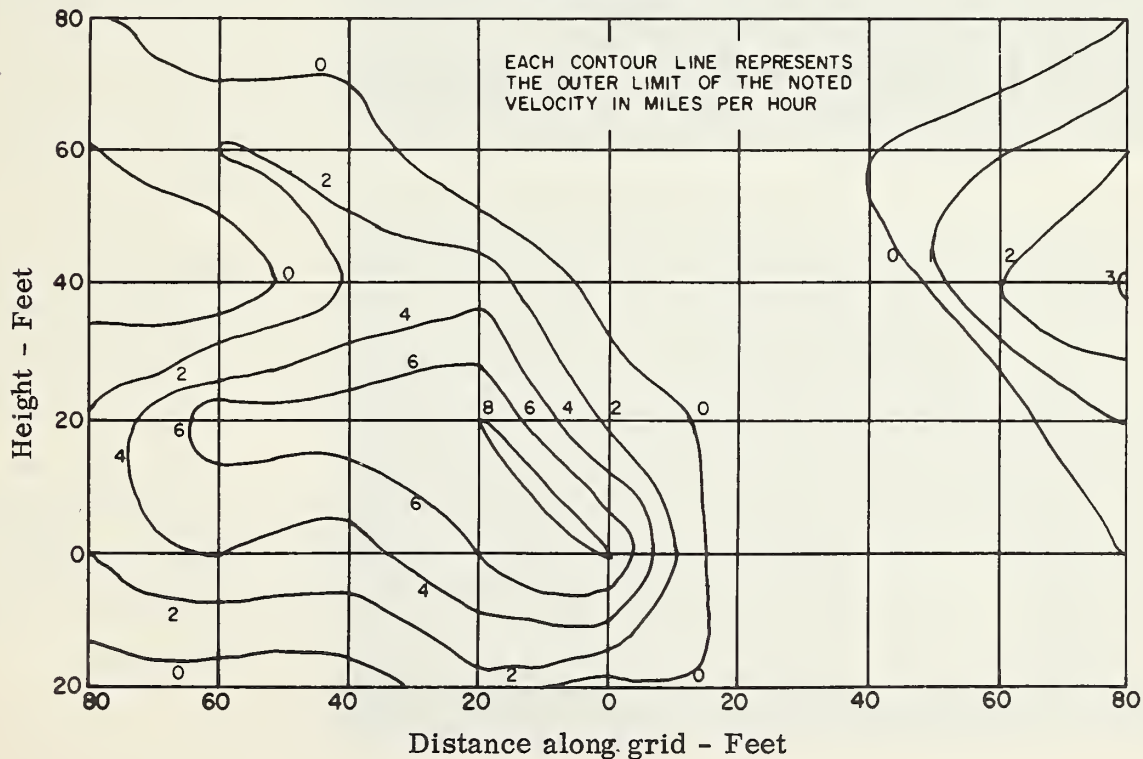


AIR VELOCITIES WITH ROUND NOZZLE CORRECTED FOR AMBIENT WIND VELOCITY

AT 100 FEET



AT 200 FEET





- Starting the fire with near zero wind and two large blowers in foreground ready to go.



- After 5 minutes, airstream is impinging on upper part of smoke column. Blower is to left; air is still.



- Smoke is carried back on top with wind 2 to 3 mph from rear and right of photographer. Note that the smoke is again pushed to left after leaving the influence of the blower airstream.

SMOKE TESTS

The smoke tests were conducted to observe operation on a fire front and visually determine the effect of the airstreams on a smoke column.

Fire and smoke were produced by burning diesel fuel in gallon cans. Five hundred cans of fuel and 100 rubber tires were laid out in a "T" pattern. The tires were added to give a black smoke for photographic purposes. Chips and shavings were scattered over the ground in the fire area to simulate leaves and trash. Weather conditions were recorded at a station approximately 200 yards to the northwest.

Square nozzles were used throughout the smoke tests.

NEAR ZERO AMBIENT WIND WITH LARGE BLOWER

During this test only the northsouth line was ignited. Wind conditions were extremely calm as the test began. (See the First Phase of the Smoke Test layout on page 12.)

The machines were first operated at 300 feet from the fireline and were aimed upward 15 degrees above the horizon. Within 5 minutes the smoke column was forced back away from the blowers.

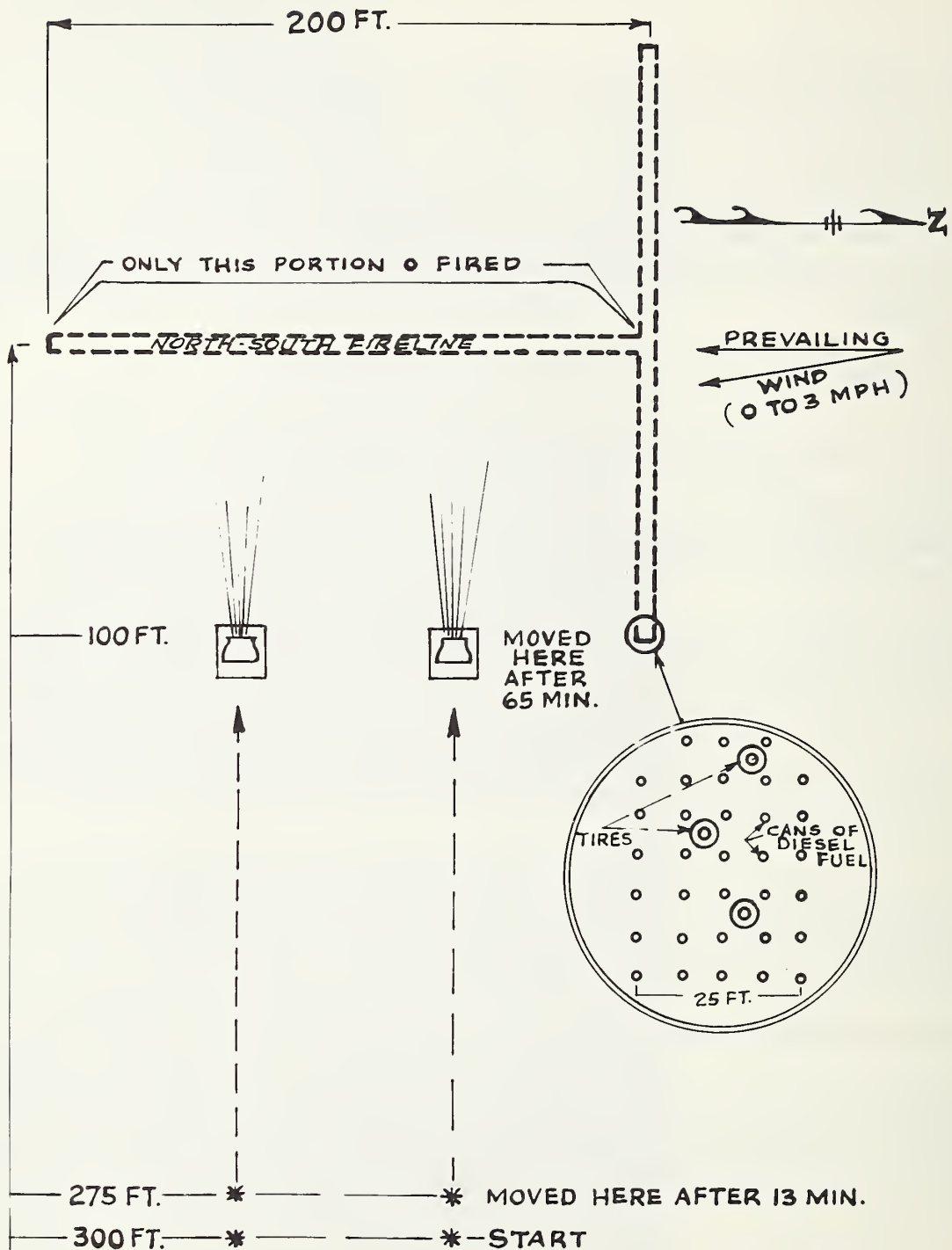
A few minutes later a breeze began out of the north and gradually increased to nearly 3 mph before this test ended. The airstream continued to force the smoke back. However, once the smoke was clear of the blower influence, it followed the ambient wind.

The objective was to cut off the rising thermals from the fire and thus reduce drafts feeding the fire. Concurrently, the airstream was to direct any rising sparks away from the blower side. In the prevailing calm and light cross-wind conditions, the blowers were successful.

TURBULENCE CHECK

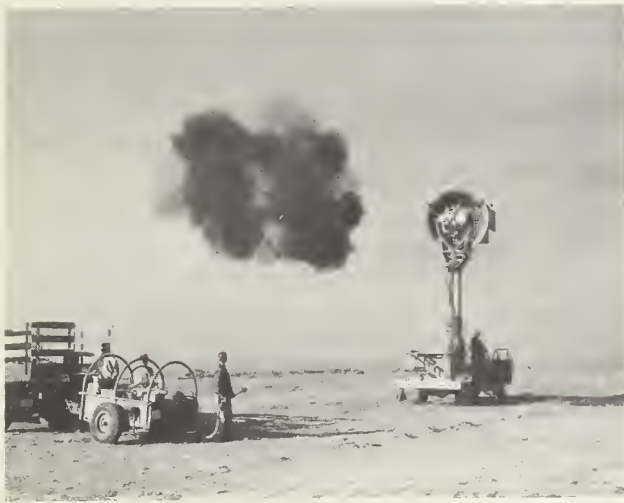
After 65 minutes, the machines were moved up and operated 100 feet from the fireline. The airstreams were gradually lowered until they impinged directly on the fire. No chips or ground litter was swirled or carried back toward the blowers. There was little turbulence and no indication of clamshell effect.

SMOKE TESTS
(FIRST PHASE)
WITH NEAR ZERO WIND



TEST SITE PLAN

- Producing puffs of smoke with diesel flame thrower.



- Smoke puffs to rear of blower.

CLAMSHELL CHECK

During the smoke tests, while the wind was calm, close observation was made of air movement over the area on the blower side of the fireline. A diesel flame thrower was employed to send up black puffs of smoke to determine the characteristics of these movements.

Along the airstream the smoke was entrained. Most of the blower air supply was drawn from above and to the rear but could not be traced beyond 50 feet. No other repetitive influence could be found, although one puff to the south of the fireline drifted a short distance toward the blower until it was dissipated. No clamshell pattern was ever established.



■ Operating in cross wind 6-7 mph rear and right of photographer. Note control fire in left foreground.

CROSS WINDS WITH LARGE BLOWERS

During the Second Phase test both the north-south and east-west lines were ignited. (See the Second Phase, Smoke Test layout on the following pages.) The wind blew from approximately 20 degrees north of due west. It was somewhat gusty and averaged from 6 to 7 mph.

A control fire was set 300 feet to the northwest so that the smoke would pass to the rear of the blowers and provide an unaffected smoke column.

The wind machines began operating 200 feet from the fireline with the blowers pointed upward at about 15 degrees above the horizon. The west blower was pointed southwest to compensate for the west wind. After 10 minutes the machines were moved up to 100 feet from the fireline. Later the blower aimings were varied in an effort to influence the air movements over the fire.

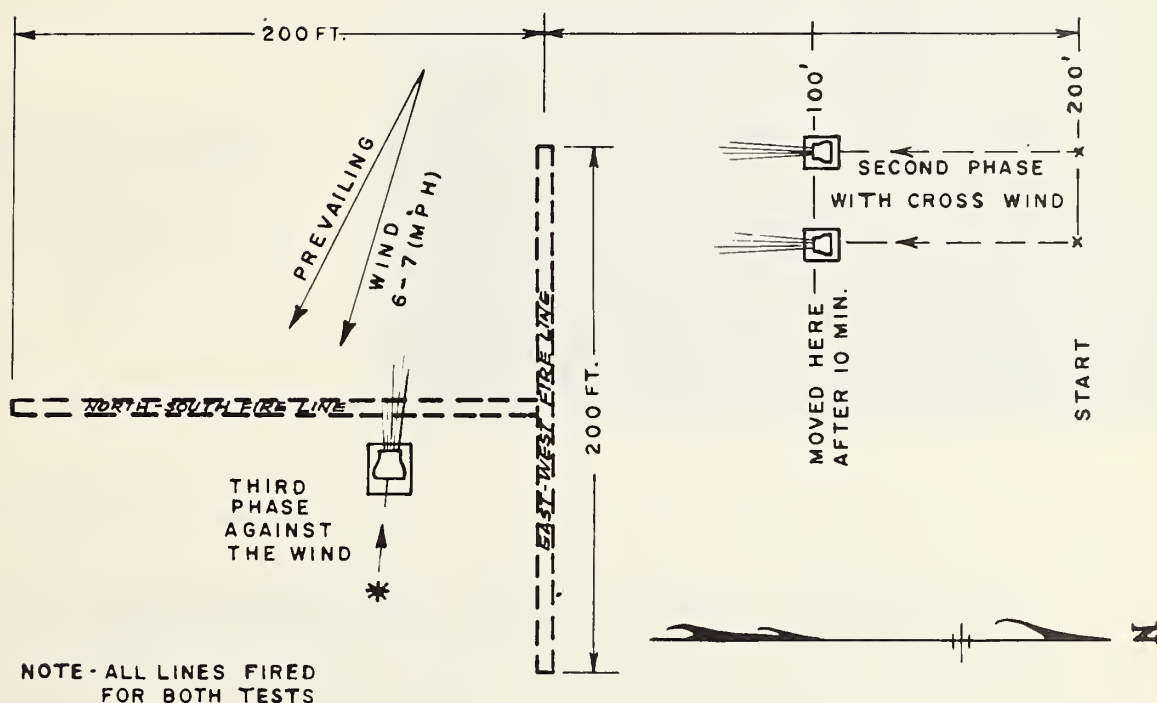
The objective here was to cut off the rising smoke column and eliminate rising sparks from falling into the area fronting the blowers. The airstreams were able to compress the front side of the smoke cloud slightly and would have prevented sparks from falling on the front side. The blowers had little effect on either the height or direction of the smoke column. Within a mile the smoke from the control fire converged with the smoke from the test fire.

When an airstream was directly impinged on the fire, some turbulence was noted. Crumpled burning paper was swirled about but not toward the blower. Chips and shavings were not significantly moved.



■ Close-up of airstream effect on smoke column. Wind 6-7 mph directly to the rear of the photographer. Note compression of smoke column on front side and convergence with control smoke in the distance.

SMOKE TESTS (SECOND AND THIRD PHASE) WITH NEAR ZERO WIND



TEST SITE PLAN

HEAD WINDS WITH THE LARGE BLOWERS

The Third Phase was a continuation of the cross-wind tests. Conditions of the wind and fireline were unchanged. (See Third Phase of the Smoke Test layout in Test Site Plan above.)

The blowers were moved to a position 100 feet east of the north-south line and put into operation opposing the west wind. Shortly after the test began, a hydraulic control failure put the south machine out of action. The remaining blower was then moved to within 10 feet of the line. Various aimings of the blower were tried to determine the most effective position.



■ Operating against wind at 100 feet, Third Phase. Machine in foreground is temporarily out of action due to hydraulic control system failure.

The airstreams had no appreciable effect on the smoke until the one machine was moved to the 10-foot line. Then the one blower provided an opening in the smoke and dispersed it over a width of about 20 feet. Even at this close range, the turbulence was not pronounced enough to reach the machine. Chips were not swirled on the ground to where any tended to be blown back toward or around the machine. No clamshell effect was developed.

■ Single machine operating 10 feet from fire-line. Note small column of smoke being deflected upward.



■ Four machines in operation. Note that the smoke column was compressed on the blower side and shifted about 20 feet. It then rose vertically.



SMALL BLOWERS

These small blowers were observed on the fire with near zero ambient winds. Four units in operation together were not powerful enough to create a general wind effect. When directed at the base of the fire, the air currents fanned the flames vigorously.

Directional control of the airstream was good. Ten mph velocities were measured at 20 feet from the blower.

Consensus was that they could have application in aiding the start of backfires or in burning out islands within the fire. They could also be useful in slash burning. These units were light and easily carried by an individual.



■ An airstream from a single blower impinging on fire. Note intensity of flame.

WATER DISPERSION

Water was injected at the blower discharge to observe the effectiveness of airstream dispersion. The airstreams were directed over clear paved areas where water fallout patterns could be readily observed. Wind conditions were calm.

THE LARGE BLOWERS

A water dispersion manifold had been mounted on each blower nozzle. Each manifold contained five tees into which were fitted 45-degree elbows and 1-inch pipe nipples. The nipples, acting as nozzles, directed the water downward into the airstream.

Water was supplied from a 4500-gallon tanker. A pumping station provided slightly over 250 gallons per minute to each blower. Flow rate was determined by the running time required to empty the supply tanker.



Both machines were operated from points 60 feet apart. The blowers were aimed upward to 20 degrees with airstreams slightly converging.

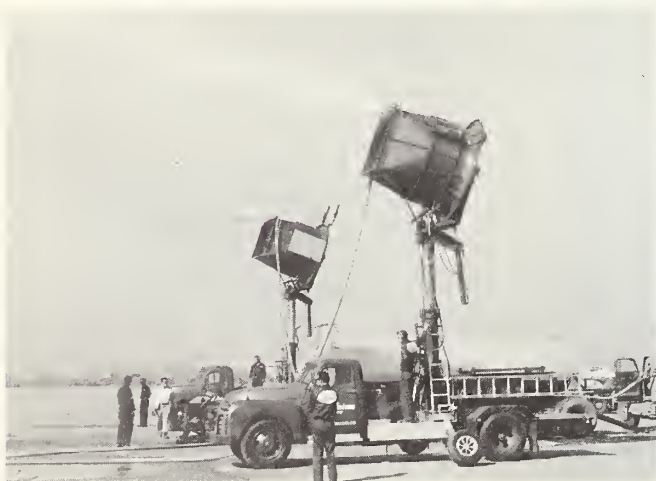
A heavy rain pattern was produced starting 50 feet from the blowers and extending to 150 feet. From there a heavy soaking mist extended to 315 feet with a width of 75 to 100 feet.

The rain-laden airstream had considerably more reach than a comparable dry airstream. Velocity was 7 mph at 300 feet compared to 3 mph with dry air. The increase in mass, due to the water, as well as the increase in density from cooling, could account for the difference.

■ Water manifold and nozzles fitted to blower.

■ Large blowers dispersing water.

■ Spray trajectory leaving blower.





Later a 25-gallon per minute nozzle stream was injected into the airstream of one blower. A good rain was produced at about 150 feet, but restricted to an area approximately 15 by 50 feet.

■ Small nozzle stream being dispersed by the blower.

THE SMALL BLOWERS

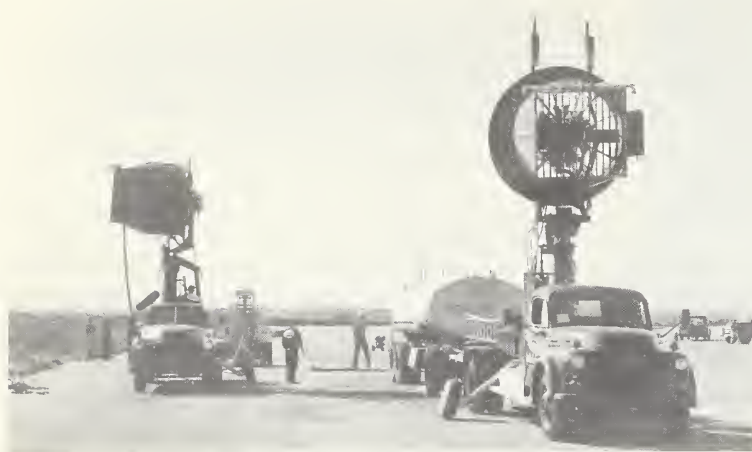
On November 1, 1960, a water-injection test was held with the 18-inch blowers at the Arcadia Work Center in Arcadia, California. Various water sources were used to introduce water into the airstream by putting it directly into the fan and by directing it into the airstream leaving the blower outlet.

Results ranged from a pattern 25 feet long and 5 feet wide using the water from a backpack unit, to a pattern 40 feet long and 6 feet wide with a stream from a 1-inch hose under hydrant pressure. At best, this method of water dispersal did not improve upon what could be done with the hose or backpack unit alone.



■ Water pattern on the pavement produced by small blower dispersing water from backpack stream.

BENTONITE DISPERSION



- A jury rig for applying bentonite while moving. The machine in the foreground pulled the retardant trailer while the pump, on the fork lift, fed bentonite to the second blower unit for application.



Bentonite slurry was injected into the airstream of one large blower to study the possibility of applying fire chemicals in the same manner as with water. Applications were made with the blower, both standing and moving. The machines were operated at the edge of the paved surface with application onto a target area covered with dry grass and growing tumble weeds. The wind was calm.

At a standstill, the blower unit completely covered an area starting 55 feet from the machine and extending to 120 feet for a width of 30 feet. The brush was lightly covered for an additional 25 feet. The bentonite was carried on top of the airstream and fell out as rain in the same manner as the water had been dispersed. The retardant covered the brush very well in the main area of coverage and penetrated into the foliage with very little run-off onto the ground.

While moving along the edge of the field, the machine applied bentonite in the same pattern and distances as when at a standstill. The rig moved 100 feet in 2 minutes, or 50 feet per minute, with adequate penetration. Coverage was more uniform than either by air drop or by nozzles on the ground. A limiting factor was the inability of the machine to satisfactorily cover the first 50 feet. Changing blower speed, altering pump pressure, or aiming the blower did not give close-in coverage.

- Target area treated with bentonite. Note untreated area in foreground.

COMMENTS

THE LARGE BLOWERS

The overall control of the wind machine was good. Directional control was excellent. The airstreams could be precisely aimed. Swirls and eddy currents along the airstream were at a minimum. Clamshell patterns did not develop.

With a well-channeled and directed airstream, it is unlikely for recirculation to occur. The discharged air is projected well away from the machine and additional air for the blower can be more easily drawn from the vast air mass above and behind the machine. It would appear that the only exception would be where a direct head wind would bend the airstream about and cause it to feed the area immediately behind the blower. At ground level even this disturbance would be minimized with the blower elevated as it is.

The greatest limitation of these machines was in the power available to change or stop ambient winds. While they were effective at great distances and could move vast quantities of air when the wind was calm, they were extremely limited when the wind increased appreciably. As illustrated in the Smoke Tests, when the wind was calm the blowers cut off a large smoke column and carried it in excess of a half mile. But, by contrast, the effect was small in altering a 6 to 7 mph. cross or head wind.

The kinetic energy required in an airstream to negate a wind increases with the third power of the wind velocity. The illustration on the following page provides a visual comparison of the energy required at various wind velocities and at various distances. The areas in the graph are proportional to the energy available and were obtained by computing the kinetic energy of the airstream.

A 20-mph wind has 1,000 times more kinetic energy than at 2 mph, or 1,000,000 times more than at 0.2 mph. To oppose these winds with a fluid mass requires equal quantities of energy.

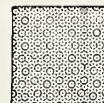
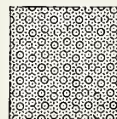
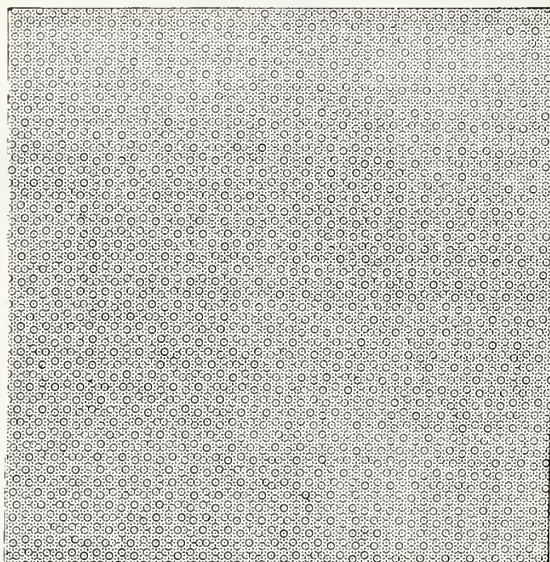
These vast differences in energy requirements give a clue as to the success of the blowers under calm conditions compared to their ineffectiveness when winds approached 10 mph. The magnitude of the job to be done at the higher velocity was thousands of times larger.

Effectiveness against winds also falls off rapidly with distance. With either the round or square nozzle, over 96 percent of the airstream kinetic energy was lost at 200 feet from the machine.

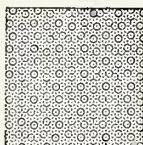
The concept that an airstream can be squirted through air similar to a water stream from a nozzle is somewhat misleading. The reach distances are not

COMPARISON OF HEAD WIND CROSS SECTIONS WHICH
COULD BE NEUTRALIZED BY AIRSTREAM - BASED ON ALL
KINETIC ENERGY AVAILABLE WITH SQUARE NOZZLE

2 MILES
PER HOUR WIND



5 MILES PER HOUR WIND



10 MILES PER HOUR WIND



15 MILES PER HOUR WIND



20 MILES PER HOUR WIND



AT BLOWER

100 FEET
FROM
BLOWER

200 FEET
FROM
BLOWER

comparable because of the great difference between the weight and viscosity of the projected air or water stream. It would be more correct to compare the action of airstreams in air to water discharged from a nozzle below the water surface. Here, as in the airstream, the fluid being discharged would be the same as the fluid into which it is projected. On this basis, the two may be compared.

In a still pond a jet of water can mildly influence a large amount of water just as the airstream can affect a vast amount of still air. In the ocean tides or in a fast-moving stream, the energy of a large jet of water would soon be dissipated without noticeable effect, just as the airstream was of little consequence in a brisk wind.

Ambient temperatures ranged from 47°F in the early morning to 88°F in mid-afternoon. Because of the cooler, denser air in the calm early morning, some advantage was gained in handling the smoke column. This advantage had decreased in the afternoon against the 6 to 7 mph wind. On going fires, with still higher ambient temperatures, the effectiveness of a dry airstream could be expected to decrease further.

Water injection had significant benefits in raising the available energy. Limited velocity readings at 300 feet indicated a rise from 3 to 7 mph when water was added. If the whole movement of air was proportionally increased, the available kinetic energy rose some twelve fold. This should have advantages on a going fire. For if water were added to the system, with the low relative humidities associated with extreme fire weather, the relative increased effect would be greater than experienced in these tests. However, while the increase could be easily measured, it would compensate for only a very modest rise in wind velocity.

As a footnote to this analysis it should be recognized that small errors in measurement can creep into a test of this kind. Any such errors would not change the basic concept of the test; the general magnitudes are the important factors. As an illustration consider a large change in energy level. Suppose that the blower power was doubled. The level of effectiveness would only be increased from a wind level of 5 to about 6-1/4 mph. To be equally effective when the wind velocity doubled would require a machine eight times more powerful. Such an increase does not seem practical.

Other advantages may be gained by adding water. Large volumes can be effectively directed onto some targets. When large volumes of water were added, the airstream provided a more uniform coverage at a probable greater distance than normally possible with a nozzle. When close in the conventional nozzle would be better because of the inability of the airstream to disperse water in a satisfactory manner in the first 50 feet. Small quantities of water appeared to provide little advantage.

Fire personnel observing the tests had mixed opinions regarding airstream water dispersion versus the conventional hose and nozzle. Some could see application onto blind targets. Most felt the conventional method was more flexible and less costly.

THE SMALL BLOWERS

The small blowers were light and easily moved. Their control was excellent. They fanned a fire and produced an intense flame but could not noticeably affect the ambient wind, even in groups. Neither could they dispense water significantly better than could be done by a common nozzle.

As an added note, the blowers have successfully demonstrated their ability to adequately ventilate a structure when placed in a doorway or window. Their most probable forest application would be in fanning a blaze to increase its intensity in certain backfiring or slash-burning operations.

CONCLUSIONS

1. Both the large and small blowers were specialized units suitable for only a limited number of tasks.
2. The large blower was capable of cutting off a smoke column within its influence or of moving a large volume of air when the wind was calm but was extremely limited when wind velocities exceeded 5 mph.
3. Power requirements to overcome a mass area of brisk ambient wind are too large for the capabilities of any practical-sized blower.
4. Water or fire chemicals can be effectively applied within the drop pattern of the large unit. It should prove effective in applying fire chemicals to highway cut banks and adjacent areas.
5. The small blower will increase the intensity of a flame and could prove to be an aid in backfiring and slash-burning activities.
6. No significant clamshell or recirculating wind current pattern could be produced.
7. In other than brisk head wind conditions, the airstreams would be effective in reducing sparks dropping on the blower side of a fireline.

APPENDIX I

A. SPECIFICATIONS OF LARGE BLOWER

ENGINE: Make: Continental
 Model: W-670-9A
 Horsepower: 250 at 2500 rpm
 No. of cylinders: 7
 Air cooled

BLOWER: Type: Axial flow
 Propeller: 72-inch, 2-bladed
 Vertical tip angle: 130°
 Wt. blower assy: approx. 2000 lb
 Square nozzle opening: 52" x 52"
 Round nozzle opening: 61" dia.
 Rated flow: 204,000 cubic feet/min.

B. SPECIFICATIONS OF SMALL BLOWER

ENGINE: Make: Clinton
 Model: 500-2300-022
 Horsepower: Maximum 2.5 at 3600 rpm
 Rated 2.2 at 3200 rpm
 Type: One cylinder 2-stroke cycle
 Air cooled

BLOWER: Type: Axial flow
 Propeller: 18-inch, 7-bladed
 Square nozzle opening: 12" x 12"
 Total weight: (Blower and Engine) 45 pounds

APPENDIX II

TABLES AND COMPUTATIONS

CROSS-SECTIONAL AREA OF EACH VELOCITY GRADIENT AS DETERMINED FROM GRID TARGET ISOGRAMS

100 Feet From Square Nozzle

<u>Velocity, mph</u>	<u>Area, sq. ft.</u>
2-4	2388
4-6	1068
6-8	576
8-10	480
over 10	144

200 Feet From Square Nozzle

<u>Velocity, mph</u>	<u>Area, sq. ft.</u>
1-2	1950
2-4	2442
4-6	1314
6-8	654
8-10	330
over 10	12

100 Feet From Round Nozzle

<u>Velocity, mph</u>	<u>Area, sq. ft.</u>	<u>Velocity, mph</u>	<u>Area, sq. ft.</u>
2-4	372	12-14	120
4-6	456	14-16	156
6-8	512	16-18	96
8-10	244	18-20	72
10-12	204	over 20	24

200 Feet From Round Nozzle

<u>Velocity, mph</u>	<u>Area, sq. ft.</u>
0-2	3678
2-4	1668
4-6	1560
6-8	672
over 8	66

SIDE DIMENSIONS OF SQUARE CROSS-SECTIONAL WIND AREA
WHICH COULD BE COUNTERACTED BY LARGE BLOWER.
(ASSUMING ALL KINETIC ENERGY UTILIZED.)

Velocity	At Blower	Square Nozzle		Round Nozzle	
		At 100 ft.	At 200 ft.	At 100 ft.	At 200 ft.
1/2 mph	13600 ft.	2780 ft.	2450 ft.	4650 ft.	2100 ft.
1	5000	1020	900	1705	773
2	1700	348	306	582	273
5	431	88	78	147	67
10	152	32	27	52	24
15	83	17	15	28	13
20	54	11	10	18	8

RELATIVE KINETIC ENERGY AVAILABLE AT TARGET
COMPARED TO ENERGY AT BLOWER OUTLET. *

100 feet from Square Nozzle - 4.2%
200 feet from Square Nozzle - 3.2%
100 feet from Round Nozzle - 11.6%
200 feet from Round Nozzle - 2.4%

*Energy at blower outlet based on computations from data contained in letter from Controlled Airstreams dated May 21, 1960.

METHOD FOR COMPUTING KINETIC ENERGY OF AIRSTREAMS

$$KE = 1/2 mv^2 \quad (1)$$

where KE = kinetic energy

m = mass

v = velocity

The mass of gas crossing a given line is equal to the volume in suitable units.

$$V = Av$$

where A = cross-sectional area

Substituting

$$\begin{aligned} KE &= 1/2 mv^2 = k (Av)v^2 = K Av^3 \\ &= k (Av)v^2 \end{aligned} \quad (2)$$

$$= k A v^3 \quad (3)$$

where k = constant

Since only a comparison of values and ratios are to be considered, there is no need to determine k.

SAMPLE COMPUTATIONS

1. KE at blower

given* 1. Volume at blower = 204,000 cfm

2. Velocity at blower = 100 mph = 8800 fpm

from (2), $KE = k (Av)v^2$

$$= k (204,000) (8800)^2 = 1.58k \times 10^{13}$$

2. KE at 100 feet from blower using square nozzle

Cross-sectional area (2-4 mph) = 2388 sq. ft.

$$\text{rms velocity}^{**} = \sqrt{\frac{v_1^2 + v_2^2}{2}} = \sqrt{\frac{4 + 16}{2}} = 3.16 \text{ mph} = 278 \text{ fpm}$$

from (3), $KE = k A v^3$

$$= k (2388) (278)^3 = 5.13k \times 10^{10}$$

NOTE: Total KE = Sum of KE's for each gradient level.

3. Relative KE at target

$$\text{Relative KE} = \frac{\text{KE at target}}{\text{KE at blower}} \times 100 \quad \text{percent}$$

*Letter from Controlled Airstreams dated May 21, 1960.

**root-mean-square velocity.

